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VERSION 1

USER'S MANUAL  
FOR  
NICKEL CADMIUM BATTERY EXPERT SYSTEM  
NAS8-35922

DEVELOPED FOR  
NASA/MARSHALL SPACE FLIGHT CENTER  
HUNTSVILLE, ALABAMA

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## SECTION 1. SCOPE

### 1.1 Identification.

This is the User Manual for NICBES - Nickel Cadmium Battery Expert System. It documents the control for both NICBES subsystems; the Expert System and the Data-Handler.

### 1.2 Computer System Materials.

The system configuration for NICBES at Marshall Space Flight Center (MSFC) includes a DEC LSI-11 which sends telemetry to a dedicated IBM-PC AT over a RS232 connection. The IBM-PC AT has a hard disk with 2 disk drives. Both ARITY PROLOG - Version 4.1 (256K) and MICROSOFT C (256K) need to be installed on the IBM-PC AT according to the specifications of the respective installation manuals. Both have been purchased by MSFC. ARITY PROLOG is setup under the root in a directory called PROLOG (Path: C:\PROLOG). The NICBES directory will contain all the PROLOG programs necessary to run the Expert System. MICROSOFT C is setup under root with all the 'C' programs for the Data-Handler in the directory called USR (Path: C:\USR). The IBM operating system, DOS, is assumed to be installed under the root in a directory called DOS (Path: C:\DOS). In addition the Star-SD-15 printer is linked to the IBM-PC AT for hardcopy capability.

## SECTION 2. APPLICABLE DOCUMENTS

Program Maintenance Manual for NICBES - October 1986

IBM-PC AT Manuals

ARITY PROLOG Manuals

MICROSOFT C Manuals

## SECTION 3. SYSTEM OPERATION

### 3.1 Power On/Off.

Follow the standard procedures for turning the IBM-PC AT on/off as directed in the IBM Installation and Setup Manual.

### 3.2 System Initiation.

Before running NICBES, the RS232 connection must be in place with correct 'mode' setting on the IBM-PC AT (mode = com1;96,n,8,1). This command is placed in the AUTOEXEC.BAT file along with other system settings including path settings for ARITY PROLOG and MICROSOFT C. The CONFIG.SYS file is defined with files=15, buffers=20. Refer to Section 3.4 for initiation of the Data-Handler and the Expert System.

3.3 General Information. Soft rebooting the IBM-PC AT is done by simply depressing the Ctrl, Alt and Del keyes simultaneously. Hard boot is accomplished by turning the power off, waiting 10 seconds, and then turning the power back on.

### 3.4 Operating Procedure.

Having configured the IBM-PC AT as described above, you are ready to run NICBES. The system operates in two modes.

First, the Data-Handler captures the telemetry from the DEC LSI-11 every one minute for 12 or more orbits where each orbit lasts 96 minutes. This lengthy process is required to build the historical data files for the Expert System. To start the Data-Handler go to C:\USR. Then enter 'data dhl <CR>' where data\_dhl is the name of the Data-Handler's executable. Check to make sure the DEC LSI 11 is sending telemetry. The Data-Handler will synchronize with the incoming data. Messages will appear on the screen after every completed orbit. Error messages, as no communication or consecutive incomplete telemetry runs being received will also be printed to the screen. These conditions, as well as fault alarms, cause the Data-Handler to automatically exit after the appropriate data files are written. If no one is available to monitor the displays, enter '^P' and all screen messages will also be written to the printer. To stop this process, simply enter '^P' again. This will give you a log of the Data-Handler's actions. Do not terminate the process until at least 12 orbits have been recorded. To stop the Data-Handler enter '^C <CR>'. It will take a few seconds to finish at which time you will be returned to DOS.

The second mode of operation is the Expert System. As soon as the data files have been created by the Data-Handler the Expert System is ready for execution. First go to the NICBES directory. Then enter 'api<CR>'. All the PROLOG programs (start.prg, faultd.prg, status.prg, advice.prg, showpak.prg, grafpak.prg) as well as the current data files (curf(N).dat, N = 1 to 3) and fault.dat, are loaded by the initiation program called 'prolog.ini'. This program also starts the Expert System with the command 'begin.'. When the Expert System stops, all the data files are automatically deleted from this directory. Data file archiving is the responsibility of the user, see Section 3.7 for further information on this topic. The Expert System will begin either with Fault Diagnosis or with the Main Menu depending on the fault flag. Except for Fault Diagnosis, the user interface, made up of menus, drives the system. The user can traverse the Expert System by inputting selections to menus in the format of an item number or a yes/no response, followed by a <CR>. After quitting NICBES, you will be returned to DOS.

### 3.5 Input/Output.

There are no Login/Logoff or password procedures. After booting the IBM-PC AT, you are ready to begin. The only user input after starting the Data-Handler is the termination of the process after at least 12 orbits have been recorded by entering '^C'. Input to the Data-Handler is in the form of telemetry from the HST Testbed as described above.

The Expert System in turn utilizes the output files from the Data-Handler as its input. There is also user input in the form of menu selections. The Expert System can return fault diagnosis, status of the batteries (1-6), advice on battery (1-6) condition (1-3), and plots (1-12) of battery (1-6) parameters. Which screens will be seen depends on the choices selected by the user, except for the fault diagnosis which is available only when the fault flag = 1, and is activated automatically. See Figure 1 for the Menu Flow Diagram.

Let us go through a typical session with the Expert System. First, if there is a fault, a Fault Diagnosis header will be written to the screen. Each condition checked, as well as the resulting evaluations, make up the Fault Diagnostic Report. If the user wishes more information or if there was no anomaly detected, the Main Menu will appear as follows:

#### NICBES MAIN MENU

1. PLOTS AND GRAPHS
2. BATTERY STATUS
3. ADVICE OF RECONDITIONING, WORKLOAD AND CHARGE
4. QUIT NICBES

ENTER CHOICE (e.g. 1<CR> ):

Selection 4 will return you to DOS. Choices 1 - 3 will next prompt you for a battery number 1 - 6. You can go through each Expert System Module with each battery. Header information is printed for each module so that you always know where you are in NICBES.

Plots and Graphs will give you a choice of 12 plots to view. Again you can generate as many as you want for a given battery.

#### GRAPHICS MENU FOR BATTERY N

- 1--Battery Voltage at EOD for last 12 orbits
- 2--Battery Voltage at high in-charge for last 12 orbits
- 3--Recharge ratio for last 12 orbits
- 4--Cell Voltages at EOD; high, low, average for last 12 orbits
- 5--Cell Voltages at high in-charge; high, low, avg, last 12 orbits
- 6--Cell Voltages at EOD for latest orbit
- 7--Cell Voltages at high in-charge for latest orbit
- 8--Average Battery Temperature for latest orbit, each 2 min
- 9--Average Battery Temperature for last 12 orbits
- 10--Cell Pressures at EOC and EOD for latest orbit
- 11--Time on Trickle Charge for last 12 orbits
- 12--Battery Current during reconditioning, 1 orbit, each 2 min
- 13--Quit for Another Battery Selection
- 14--Quit to Main Menu

ENTER CHOICE (e.g. 1<CR> ):

# NICBES MENU FLOW DIAGRAM

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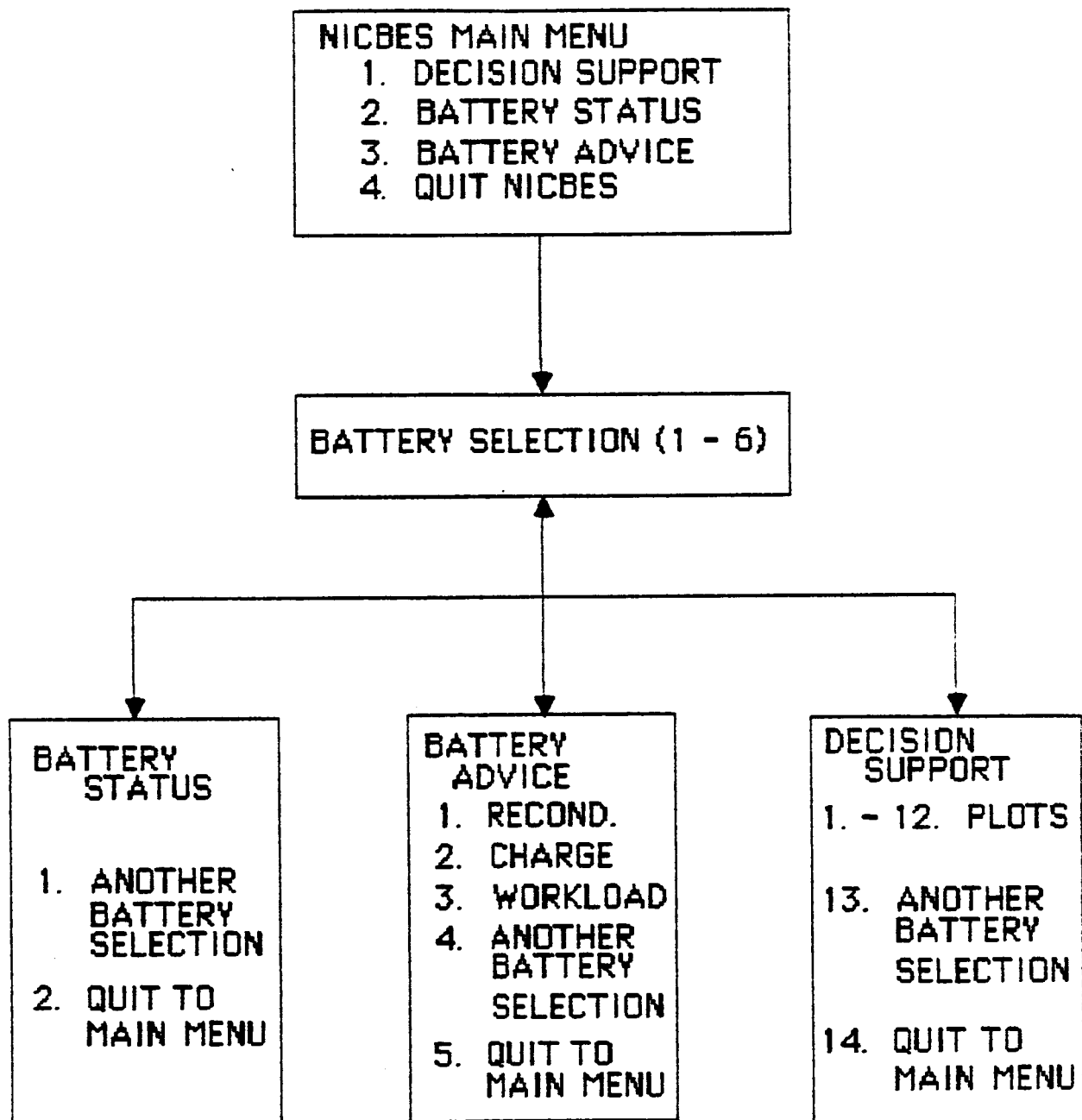


FIGURE 1

Battery Status will give the status of the selected battery. It checks battery temperatures, workload, charging, and divergence using averages of orbital data. Status Report consists of the condition being checked and the results of status analysis. The user can then opt to either select another battery or return to the Main Menu.

Advice section uses trend analysis to go into further detail on what the condition of the battery is and what preventive action should be taken.

#### BATTERY ADVICE MENU FOR BATTERY N

1. RECONDITION BATTERY?
2. CHANGE CHARGING REGIME?
3. CHANGE WORKLOAD?
4. QUIT FOR ANOTHER BATTERY SELECTION
5. QUIT TO MAIN MENU

ENTER CHOICE (e.g. 1<CR> ):

### 3.6 Monitor Procedures.

The Data-Handler can be monitored by checking the messages printed to the screen at the completion of each orbit. The message will list the orbit number for the completed orbit and the number of orbits processed so far. The process will terminate automatically if telemetry fails to cross over the RS232, an anomaly is detected or a shutdown signal is received. The Expert System operates interactively and reflects the current state.

### 3.7 Auxillary/Off-Line Routines.

Although there are no programs as such, you may want to make use of some system aids. For instance, to get a hard copy of the Data-Handler log, enter '^P' prior to initiation. You will then get a print out of each message written on the screen. To switch off this option, re-enter '^P'.

To get a hardcopy of any of the Expert System screens, hit the shift key and the PrtSc key after the report or plot has been displayed on the terminal. This utilizes the DOS GRAPHICS program.

Any or all data files can be printed using the DOS print command with the name of the file. Using the '\*' will give you more flexibility, as 'print showf\*.dat' prints all the show files.

It is advisable to archive data files for later reference. Make a directory under root, as 'mkdir data' (Path: C:\DATA). In this data directory make other subdirectories, a new one for each set of data files you want to save. Then copy the latest set of data files into this directory using the date created as a reference point. There is a data.bat command file available which will do this task for you. Simply enter 'data date' where date is in the format mm-dd-yy.

### 3.8 Recovery Procedures.

In the Data-Handler, system hang-up can only be treated by re-booting and starting over.

In the Expert System if you do get hung, enter '^C' to get back to PROLOG. When you see the prompt you can either type 'begin.<CR>' to start the Expert System again or 'halt.<CR>' to leave PROLOG and return to DOS. ARITY PROLOG supports trace and spy facilities to aid in any debugging.

### 3.9 Special Operational Procedures.

The Data-Handler and the Expert System can not execute at the same time due to IBM's single tasking limitation. In addition to effectively run the Expert System, a full set of data files is required.

### 3.10 Program/System Control.

The user has access to all the source code and can make whatever changes deemed necessary. Consult the System Maintenance Manual first and always make backups of the file prior to editing. Working knowledge of both 'C' and Prolog is required. Document all changes. Regular backups should be a part of the maintenance schedule.

### 3.11 Security.

There are no security requirements.

### 3.12 Safety.

There are no safety procedures applicable.

### 3.13 Program Inventory.

Data-Handler Programs (all written in 'C'):

datacl.bat - essentially the Makefile for the Data-Handler, it compiles data\_hdl.c and links all needed object files.

hst.h - Header file to setup global structures, matrices and arrays, data definitions, and include file names.

data\_dhl.c - Main driver which calls other routines.

data\_dhl.exe - Executable for the Data-Handler.

read\_data.c - Reads incoming telemetry (header, battery data, solar panel array and bus data).

process.c - Processes telemetry (sums, averages, minimums and maximums).

write.c - Writes processed data to output files at appropriate times.

Expert System Programs (all written in PROLOG):

prolog.ini - Automatically consulted by PROLOG when Expert System is initiated. It loads all needed PROLOG programs, copies all data files to the NICBES directory, consults current data files and fault.dat, and then starts the Expert System.

start.prg - Main driver. Calls all other routines.  
Implements User Interface in the form of menus.

faultd.prg - Fault Diagnosis.

status.prg - Gives status of selected battery.

advice.prg - Gives advice on reconditioning, workload and/or charging of selected battery.

showpak.prg - Draws any of 12 plots for selected battery.

grafpak.prg - Manipulates graphics primitives for showpak.prg

utility.prg - Miscellaneous Prolog predicates for use by other modules.

Data Files:

fault.dat - Contains a fault flag = 1 if there was a fault  
= 0 if no fault was detected.

curfl.dat - Contains the current orbit number and  
a reconditioning flag for each battery = 1 for reconditioning  
= 0 no reconditioning.

curf2.dat - Contains Phase (charge or discharge)  
Day\_min  
Current from 13 SPAs (Solar Panel Array)  
Voltage from 3 Busses  
Average Temperature from each battery (6)

curf3.dat - Contains Battery Cell Voltages (23 for each of 6 batteries)

showfl.dat (6x12) - File contains battery voltage taken at EOD per orbit for last 12 orbits.

showf2.dat (6x12) - File contains the battery voltage at high in-charge per orbit for the last 12 orbits. There are 23 cells per battery.

showf3.dat (6x12) - File contains the recharge ratio = AHO/AHI per orbit for 12 orbits.

showf4.dat (6x36) - File contains cell voltages at EOD, with the high value, low value and average of all values, in this order per orbit for the last 12 orbits. So a row contains 12 high values, 12 low values and then 12 average values.

showf5.dat (6x36) - File contains cell voltages at high-charge; high, low and average of all values, in this order, per orbit for last 12 orbits. Each row contains 12 high values, 12 low values and the 12 average values.

showf6.dat (6x23) - File contains 23 cell voltages at EOD for each battery, from the latest orbit.

showf7.dat (6x23) - File contains 23 cell voltages at high-charge for the latest orbit.

showf8.dat (6x48) - File contains the average of the six temperature sensors (degrees C) per battery, at two minute intervals (1min,3min,...95min) over the latest orbit.

showf9.dat (6x12) - File contains the average battery temperatures per orbit for the last 12 orbits. This is the average of the temperature averages in showf8.

showf10.dat (6x46) - File contains the 23 cell pressures taken at EOC and then the 23 cell pressures taken at EOD for each battery in the last full orbit.

showf11.dat (6x12) - File contains the time on trickle charge for each battery per orbit for the last 12 orbits.

showf12.dat (6x49) - File contains battery current during reconditioning, at 2-minute intervals, for last reconditioning of each battery. It is recorded every 2 minutes, only when battery reconditioning flag is 1 and only for one orbit. Column 1 contains the orbit number for which reconditioning is occurring. The file contains zeroes until a battery is reconditioned.

showf13.dat - File contains AH0 summed over discharge phase per orbit for last 12 orbits.